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Characteristics of Odour concentration from Rubber Processing Factories via Olfactometry Technique

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Malodour from raw rubber processing activities is a nuisance to the people who are residing around its vicinity. There are many sources of malodour from this industry. The gases emitted from water scrubber system are identified as one of the major contributors. The objective of this study is to characterize and understand the characteristics of odour emitted from water scrubber system by means of dynamic olfactometry. Three commercial rubber factories were chosen to be part of this study. The assessment covered mainly at dryers as point source of sampling, where the odorous compounds were transported from the dryer into the scrubber system, to control odour concentration. From three identified factories, odour concentration value ranged from 22,938 ou/m^3 to 275,985 ou/m^3 for Scrubber 1 & 2. As for odour removal efficiency, the corresponding factories showed the efficiency ranged between 48 % to 92 %. Several layers of filter were integrated, however no significant effects were observed. This may be due to the variations of material quality, sampling technique, type of scrubber and the maintenance of the abatement systems. Thus, proper design of scrubber may contribute in enhancing the odour removal. However, regulation of odour in Malaysia is yet to be developed and further investigations need to be carried out as there are limited numbers of papers written about the odour problems in the country.

1. Introduction

In Malaysia, rubber industries contribute significantly to the national economy. Being one of the larger producers of natural rubber in the world has to shoulder the liability in term of high number of public complaints for generating malodour by the raw rubber processing factories. In some cases the public complaints of malodour have resulted in Malaysian Department of Environment (DOE) issuing directives for factories to close down or to move elsewhere. As the country is fast developing economically, the need for better quality of life including air quality causes more people to be less tolerant to malodour. These complaints are mostly addressed to raw rubber processing factories, instead of rubber products manufacturing. In this sector, it is divided into two categories of productions, which are block rubber and latex concentrate producing factories. For latex concentrate producing factories, the odours are mainly attributed to hydrogen sulphide, formed during the reduction of sulphate, as sulphuric acids used for coagulating skim latex. To overcome these issues Zaid (2005) discussed several measures, such as to substitute sulphuric acids with formic or spent acetic acids. A combination of lime and ferric chloride solution was also suggested to be effective in precipitating sulphate in the effluent and the most effective way to overcome this problem is by converting the anaerobic pond to fully aerobic submerged aeration pond.

As for block rubber processing factories, malodour originates from volatile organic compounds produced from the microbial breakdown of non-rubbers during storage of the field-grade materials or

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thermal degradation during processing. The most recent paper published by Vipavee et al. (2003) reported, distinguishable smells characteristics from different forms of solids natural rubber associated with low molecular weight fatty acids (C2-C5) which included carbonyl components, nitrogen or sulphur and aromatic compounds.

Previously, Gan et al. (1975) studied that the malodorous vapours from natural rubber processing factory found it consists mainly of water vapours, ammonia, fatty acids of low molecular weight, alkenes, ketones, ester and hydrogen sulphite. These can be eliminated by condensing the hot malodorous vapours at 35 °C followed by water scrubbing. Apparently, water scrubbers are the most adopted system in raw rubber processing factories in Malaysia, to address the malodorous issue. The system normally consists of a cylindrical column with one or more layers of packing materials which act as filter. Tellerettes, spiral or any other types of packing materials function to enhance the scrubbing surface activities which subsequently reduce the concentration of odour. It was reported by Yong et al. (1987) that 97 % of odour removal was successfully achieved by using scrubber packed with plastic materials.

Since presently, there are no specific regulations to control odour emissions in Malaysia and this has motivated the DOE to collaborates with MRB to develop an odour discharge limits for all odour emitting factories by making use of the cost effective olfactometry odour testing technique. Via this technique, odour concentration will be measured at several sampling points including exhaust vent, surface emitting source, boundary and others related areas. However, in this paper, it only discusses on block rubber processing factories to understand the characteristics of odour concentration, as a term of preliminary information from raw rubber processing industries. The effects of production loads and different type of scrubber arrangement will also be covered, to have a complete picture of the scenario, since only limited literature is found on this subject.

2. Methodology

Malodorous gases were sampled at the chimney of water scrubber and are collected into 10 L nalophan bag using vacuum pump attached with eco-drum. Pre-dilution of samples are required as these samples are usually highly concentrated. Samples are required to be analyzed within 30 hours prior of sampling as recommended by standard (MS 1963:2007). Figure 1 shows the typical schematic diagram of water scrubber system with odour sampling methods. In particulars, the three respective factories have dissimilarity design of scrubber system. These possibly due to different capacity of dryers, which are tailored to their factory load of production. To evaluate the efficiency of scrubber, samples were taken from inlet and outlet of the system and compute the results, as explained by Yong et al. (1985). Table 1 shows details of scrubber system from each of the factory.

Table 1: Scrubber system of factories

Factory	No of scrubber	Stage of scrubbing (packing layer)	Factory production (Metric Tonne/day)	Air velocity (meter/seconds)
A	2	2	60	9.5
B	2	3	70	8.5
C	2	4	70	8.2

The olfactometer employed in this study is DynaScent Digital Olfactometer by EnvironOdour Australia Pty. Ltd. with dilution range is 2^2 - 2^{18} (Jiang, 2010). This method is accordance with *MS 1963:2007 Air Quality: Determination of Odour Emission by Dynamic Olfactometry* adaptation from European standard, EN 13725 (2003) *Air Quality - Determination of Odour Emission by Dynamic Olfactometry.*

Calibration results and repeatability test of instrument were performed and discussed in Figures 2 & 3, respectively.

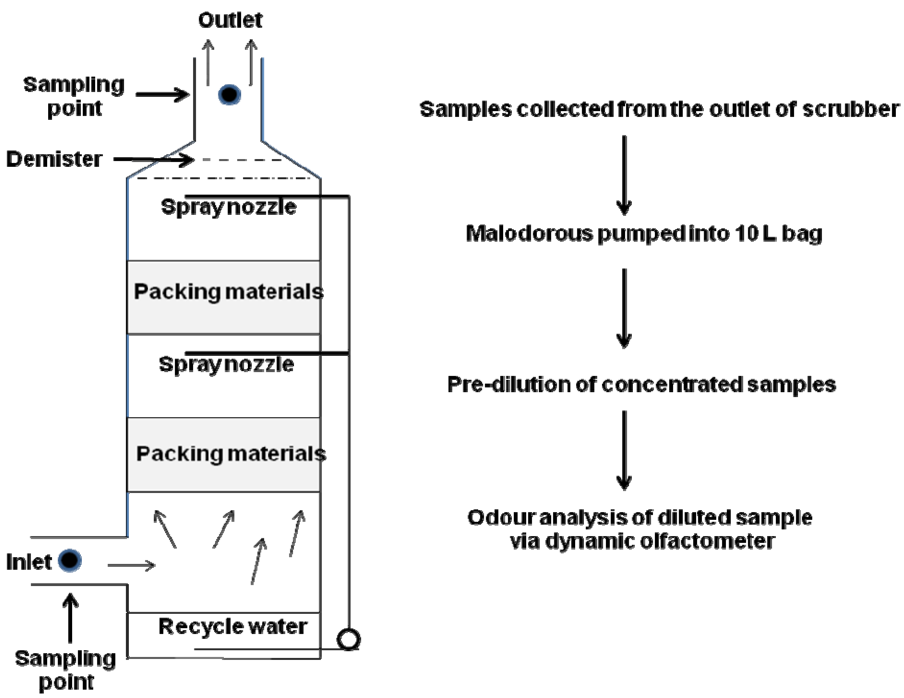

Figure 1: Schematic diagram of a typical water scrubber system and odour sampling methods.

3. Results & Discussion

From the calibration chart, results shows the accuracy and instability of instrument are smaller than 20 % and 5 %, respectively. Thus, it likely to note that the instrument is working at the optimum level of performance and able to meet the standards as required by MS 1963:2007.

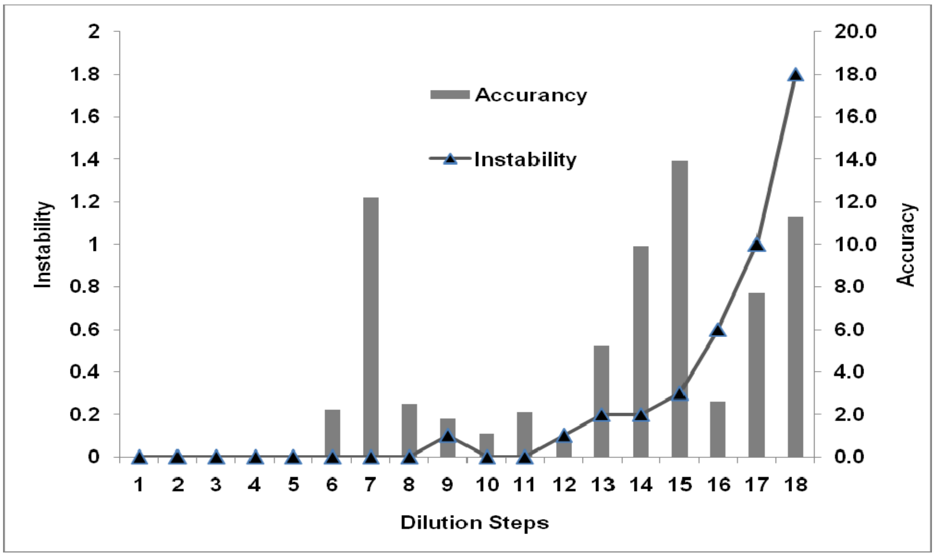

Figure 2: Calibration report of instrument

As for Figure 3, it share the repeatability results of standard gas, n-butanol. From the graph, it shows the minimum value of n-butanol concentration is 1,356 ou/m^3 and maximum value is 1,478 ou/m^3. The relative standard deviation (RSD) of testing was calculated to be 3.9 %. Therefore, the analysis is considered as valid and the instrument is reliable since RSD obtained lower than 10 %.

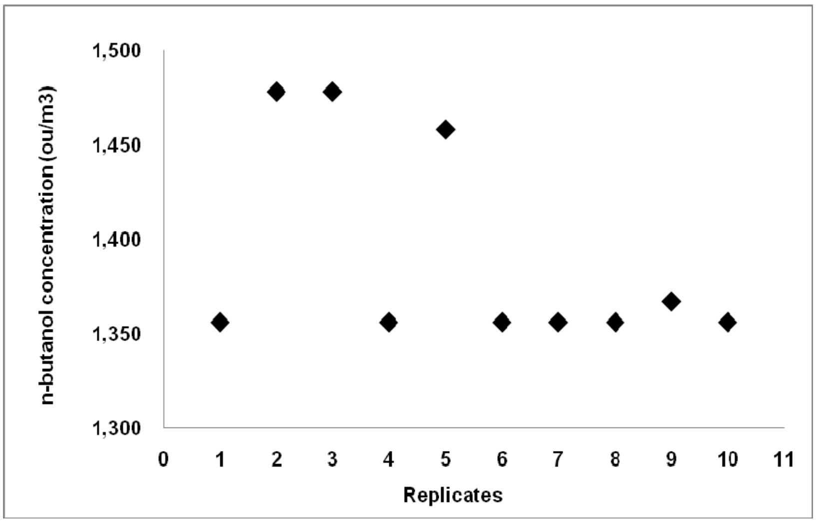

Figure 3: Repeatability test of n-butanol

Odour concentrations taken from three different factories are presented in Tables 2 & 3. Table 2 summarizes odour concentration from Scrubber 1 and Table 3 summarizes odour concentration from Scrubber 2. At a glance, all scrubbers gave the same pattern of odour concentrations where they notably increased from the first to the third time of sampling. Odour concentration values in Scrubber 1, ranged from 22,938 ou/m^3 to 259,509 ou/m^3 with an average value of 58,720 ou/m^3 for Factory A; 170,146 ou/m^3 for Factory B and 213,815 ou/m^3 for Factory C.

Table 2: Odour concentrations of Scrubber 1 for three times of sampling

Factory	Inlet (OU /m^3)			Outlet (OU /m^3)		
	1st	2nd	3rd	1st	2nd	3rd
Factory A	63,123	90,098	22,938	11,221	23,979	9,789
Factory B	118,721	200,766	190,950	14,322	34,334	21,854
Factory C	131,180	250,757	259,510	37,750	45,567	135,626

On the other hand, odour concentrations from the outlet shows Factory A and Factory B shared comparable pattern of odour reduction from both scrubbers. Nevertheless, for Factory C odour concentration was dramatically increased from second sampling to the third time of sampling. The overall odour concentration of Scrubber 1 ranged from 9,789 ou/m^3 to 135,626 ou/m^3 with an average value of 14,996 ou/m^3 for Factory A; 23,503 ou/m^3 for Factory B and 72,981 ou/m^3 for Factory C.

Table 3: Odour concentrations of Scrubber 2 for three times of sampling

Factory	Inlet (OU /m^3)			Outlet (OU /m^3)		
	1st	2nd	3rd	1st	2nd	3rd
Factory A	65,307	107,274	32,441	11,046	25,598	16,951
Factory B	168,459	275,985	181,807	19,963	58,257	16,433
Factory C	138,958	113,434	232,742	36,030	9,162	67,816

For Scrubber 2, odour concentrations from inlet ranged from 32,441 ou/m^3 to 275,985 ou/m^3 with an average value of 68,340 u/m^3 for Factory A; 208,750 ou/m^3 for Factory B and 161,711 ou/m^3 for Factory C. However, odour value for Factory C during the second time of sampling had dropped to 113,434 ou/m^3. As can be observed from the table, odour concentration from Factory A, was consistently lower compared to that of Factory B and Factory C. As for the outlet of Scrubber 2, odour concentration are ranged from 9,162 ou/m^3 to 58,257 ou/m^3 with an average of 17,865 ou/m^3 for Factory A; 31,551 ou/m^3 for Factory B and 37,669 ou/m^3 for Factory C. Variation of odour concentrations values may be due to the different production load of these factories, where 60 Metrics Tonne (MT) / day of materials used in Factory A and 70 MT/ day used in Factory B and C, respectively. Similar study was conducted by Zaid et al. (2008) where the odour concentration was detected to be 15,703 ou/m^3 for the production of 60-66 MT/ day. He also stated that there are no correlations between odour concentrations with respect to total production of factory. Nevertheless, this may be due to variations of material quality, sampling technique, type of scrubber and maintenance of the abatement systems.

Theoretically, scrubber played an important role in reducing odour concentrations from the factory. The exhaust odours from the dryer are directed upwards by suction fan to pass through the packing materials as a filter. Packing materials are inert solid material that produces large surface areas were stacked as double, triple or quadruple layered, to increase the surface activities and consequently enhance the performance of scrubber. Volatile fatty acids and volatile organic compounds were detected as abundance of compounds released from the scrubber. These obnoxious water soluble compounds travel through the packing material to have their concentrations reduced considerably and would be discharged to the atmosphere. The present of acetic, propanoic, isobutaric, isovelaric and velaric acids are compounds identified by literature previously (Zaid, 1993; Yong et al., 1985).

In this study, comparisons of scrubbing effectiveness are examined as a result of percentage of odour reduction. As calculated by the difference of inlet and outlet from each of the scrubber, Factory A showed the efficiency which ranged 48 – 83 %; Factory B was 83 – 91 % and Factory C showed the efficiency of between 48 – 92 %. These results are not in agreement with the design of scrubber as explained earlier, since it has failed to show any effects to the present of multi stage filter. Table 4 summarizes the scrubber efficiency of respective factories.

Table 4: Odour removal efficiency for different times of sampling

Factory	Scrubber 1 (%)			Scrubber 2 (%)		
	1st	2nd	3rd	1st	2nd	3rd
Factory A	82	73	57	83	86	48
Factory B	88	83	89	88	79	91
Factory C	71	82	48	74	92	71

In actual fact, various factors could have influenced the removal of malodour, where one of the important areas is the maintenance of the scrubber. Packing materials need to be cleaned comprehensively with clean water or soda solution (Zaid, 2005). As for better removal efficiency, quality of water used should be fresh and clean and it has to be replaced after several time of usage, to avoid any carryover of odour. Apart from that, there are factories willing to take their own initiative to incorporate some chemicals as masking agents into the system to trap odorous compounds from being released to the environment.

4. Conclusion

Removals of odour by the scrubber system are demonstrated in this study. Odour concentration from the inlet of the scrubber recorded to be between 22,938 ou/m^3 and 275,985 ou/m^3. As for the outlet, odour concentrations are recorded between 9,162 ou/m^3 and 135,626 ou/m^3. These values are higher compared to that of the previous study, as several factors might have contributed or influenced the reading. Proper design of scrubber may contribute in enhancing the removal of odour. In this study, Factory C should reveal the lowest value as they have incorporated quadruple layer of filter or packing materials. However, extensive housekeeping practice such as periodical maintenance of the scrubber must have been in place to ensure malodorous gases or compounds are completely absorbed by the water scrubber system and releasing almost clean exhaust air, minus the pollutants. This awareness need to be installed or advocated to the factory owners, as odour regulation will be imposed in Malaysia in the near future.

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